

DOCUMENT RESUME

ED 154 988

SE 024 090

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TITLE A Laboratory Exercise in Physics: Determining the Resistance of Single Resistors and Series and Parallel Combinations of Resistance.
PUB DATE Oct 77
NOTE 10p.
EDRS PRICE MF-\$0.83 HC-\$1.67 Plus Postage.
DESCRIPTORS *Electricity; *Instructional Materials; *Laboratory Experiments; Laboratory Procedures; *Physics; Science Activities; Science Education; *Science Units; Secondary Education; *Secondary School Science; Units of Study

ABSTRACT

Presented is a secondary level physics unit which introduces students to electrical resistance in series and parallel combinations, use of the voltmeter and ammeter, wiring simple circuits, and writing scientific reports. (SI)

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A LABORATORY EXERCISE IN PHYSICS:
DETERMINING THE RESISTANCE OF SINGLE
RESISTORS AND SERIES AND PARALLEL
COMBINATIONS OF RESISTANCE

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OCTOBER 1977

SE 024 090

ABSTRACT

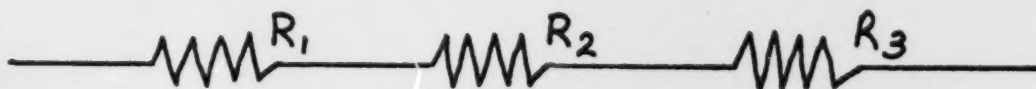
The student investigates individual resistances and series and parallel combinations of resistance using a voltmeter and an ammeter. In addition to learning about the parameters in these types of circuits, the student gains experience wiring simple circuits, gathering data, and writing scientific reports.

INTRODUCTION

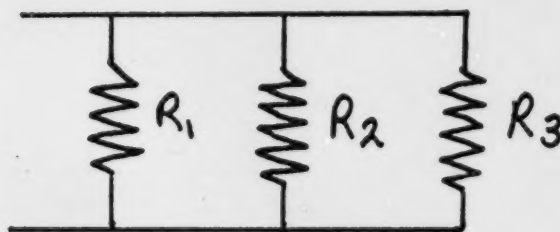
Resistors are used in electrical and electronic applications to perform a variety of functions. They are used to provide different voltages at various points in a circuit, given that the supply voltage is constant. They are used in combination with other components to provide filtering networks, etc.

In order to perform a variety of tasks, resistors are sometimes wired in series configurations, sometimes in parallel configurations, and at other times in series-parallel configurations.

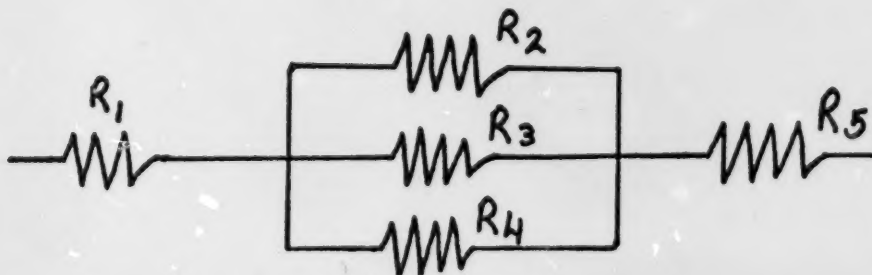
SERIES CONFIGURATION



PARALLEL CONFIGURATION



SERIES-PARALLEL CONFIGURATION



The configuration determines the total amount of resistance which is presented to the circuit. Total resistance in a series configuration may be computed using the formula:

$$R_{TOTAL} = R_1 + R_2 + R_3 \dots$$

Total resistance in a parallel configuration may be computed using the formula:

$$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

Finally, total resistance in a series-parallel configuration may be mathematically determined by using the formula:

$$R_{TOTAL} = R_1 + (\text{RESISTANCE OF PARALLEL BRANCH}) + R_5 \dots$$

$$R_{TOTAL} = R_1 + \left(\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right) + R_5$$

OBJECTIVES

1. To measure the resistance of individual resistors.
2. To measure series combinations of resistors.
3. To measure parallel combinations of resistors.

DISCUSSION

The objectives of this laboratory exercise are accomplished by making extensive use of Ohm's Law; that is, current flow is directly proportional to the magnitude of the voltage present and inversely proportional to the magnitude of the resistance.

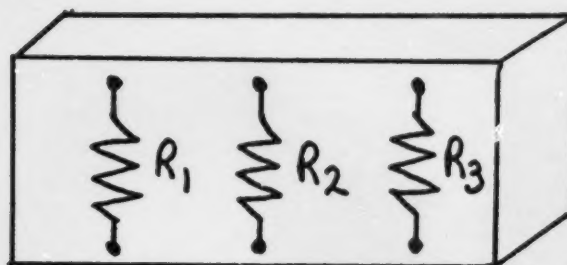
$$I = \frac{E}{R}$$

In the exercise, resistance is not measured directly. Instead, an ammeter is used to measure the current flow and a volt meter is used to measure the voltage drop across a resistor or combination of resistors.

The values obtained from the measurements are then substituted in the formula and the formula solved for resistance (R).

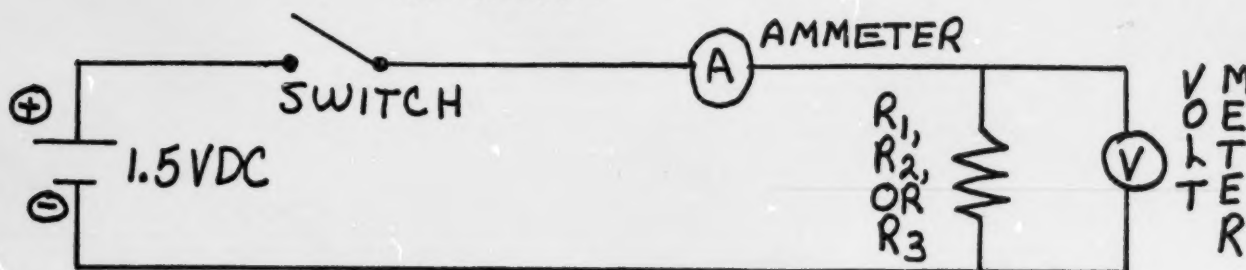
The investigation requires first, that the student determine the resistances of each of three resistors mounted on a resistor board.

FIGURE 1, Physical Layout of the Resistor Board



This is accomplished by setting up the equipment in the following configuration for each resistor.

FIGURE 2, Schematic Diagram Showing the Measurements Necessary to Determine the Resistance of One Resistor



When setting up the equipment for this investigation, remember that the ammeter is polarity sensitive (hooking it up the wrong way may result in damage to the meter). In addition, you should be aware of voltmeter polarities. Reversing the polarity on a direct current (DC) voltmeter will cause the meter to read in a reverse direction with possible subsequent damage.

The same procedure is followed when working with a series circuit

containing two resistors and again with a circuit containing three resistors.

FIGURE 3, Schematic Diagram Showing the Measurements Necessary to Determine the Resistance of Two Resistors in Series

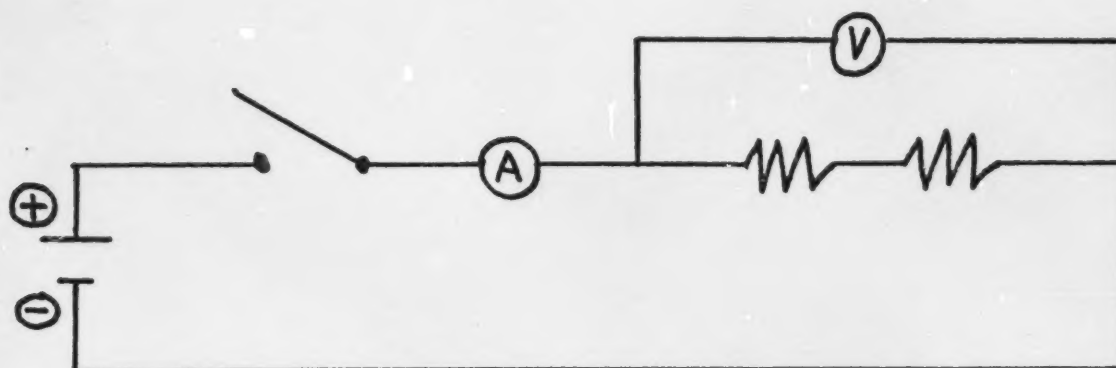
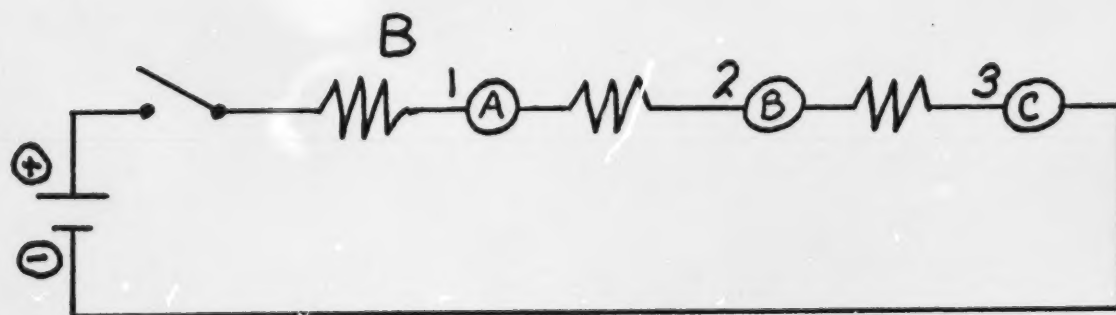
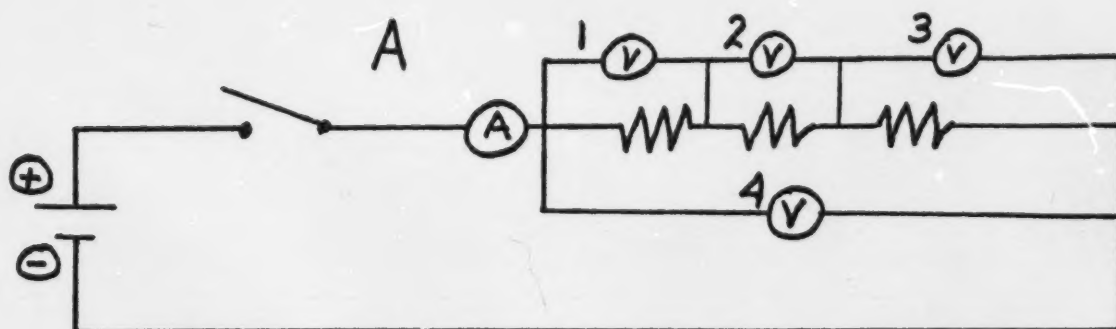


FIGURE 4, Schematic Diagram Showing the Measurements Necessary to Determine the Resistance of Three Resistors in Series.



In Figure 4 diagrams there are several different meter positions. These are marked by the numerals 1 through 4. The intent is for the student to wire one meter, first in position one and then in position two, etc. In Figure 4A then there will be four different voltmeter positions. Data should be collected at each of these positions. The same holds true for Figure 4B except that the ammeter is inserted in three different positions. The data collected by this procedure will allow the computation of resistance throughout the circuit. In addition, this procedure should lead the student to discover how the various parameters change and remain constant in a simple series circuit. These are not the only measurements which may be taken in series circuits. If it will help the reader to conceptualize what is happening, additional measurements should be taken. For example, the voltage drop could be measured across the ammeter and then, the resistance of the ammeter could be computed. What effect should this have on circuit current flow? Once a sufficient quantity of data has been accumulated from series circuits, parallel circuits should be investigated.

The circuit configuration shown in Figure 5 may be used to investigate parallel circuits.

FIGURE 5, Schematic Diagram Showing the Measurements Necessary to Determine the Resistance in a Parallel Circuit

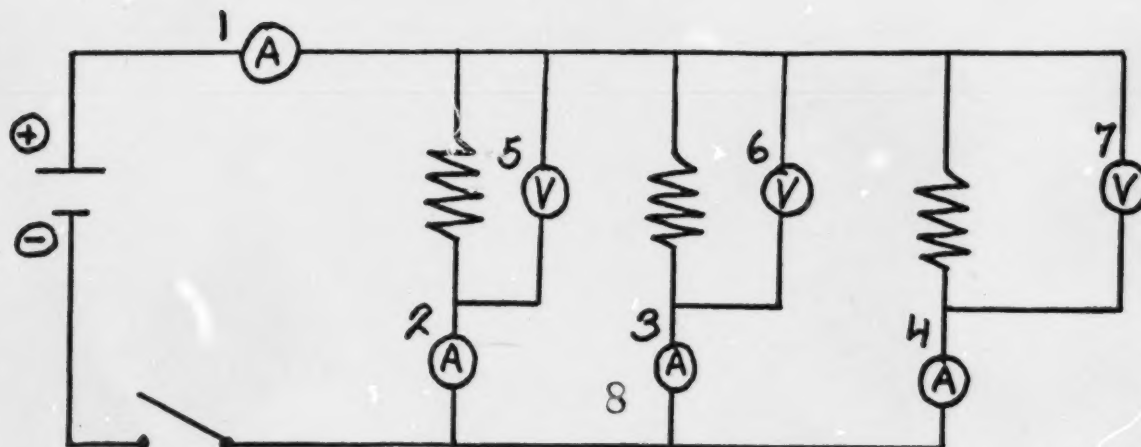
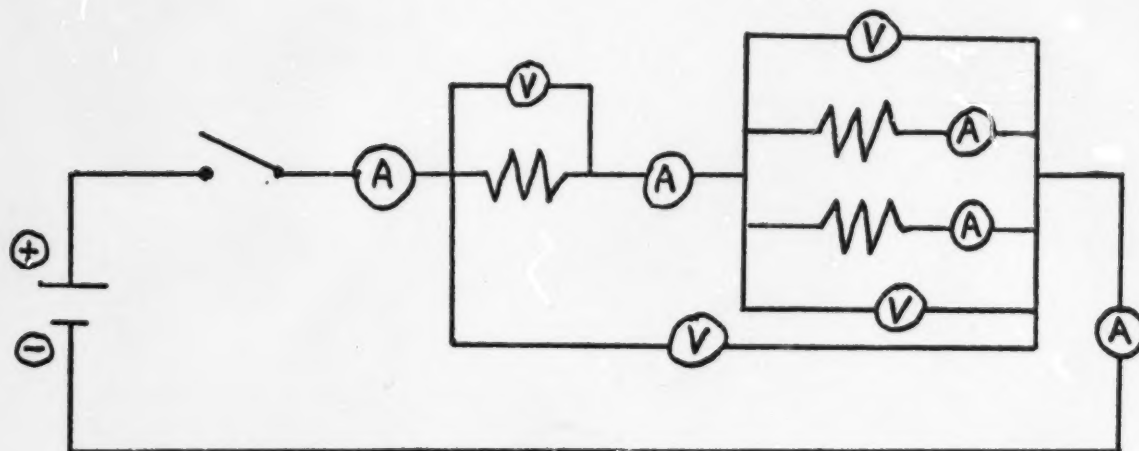


Figure 5 shows two different meters in seven different positions. The intent is for the investigator to investigate current and voltage in the circuit by inserting the meter as shown. Following the collection of data, resistance may be computed and certain conclusions drawn concerning these parameters in a parallel circuit.

Investigation of a series-parallel configuration might greatly enhance the reader's understanding of the phenomena discussed herein. An investigation of this type might be undertaken using the following circuit configuration.

FIGURE 6, Schematic Diagram Showing a Series-Parallel Configuration and Some Measurements Which Will Aid in Its Evaluation



MATERIALS

1. One $1\frac{1}{2}$ volt DC battery.
2. Three $\frac{1}{2}$ watt low resistance resistors. (It is suggested that the resistors be held to values under 10 ohms.)
3. One single pole single throw switch.
4. One voltmeter with a 0- $1\frac{1}{2}$ volt full scale deflection.
5. One ammeter with a 0-1 amp full scale deflection.
6. A quantity of clip leads or short pieces of wire.

PROCEDURE

1. Ascertain the values of single resistors (those which will be wired in series).
2. Investigate and collect data in a series resistance configuration. Using the data which has been collected, mathematically derive the values of individual resistors, and total resistance.
3. Investigate and collect data in a parallel resistance configuration. Using the data which have been collected, mathematically derive the values of individual resistors and the total resistance.
4. Which parameters change and which remain constant in a series circuit, in a parallel circuit?
5. Write a report of your findings. The format for that report should be as follows; INTRODUCTION, METHODS, DATA, DISCUSSION, and CONCLUSIONS. This should be a report of a scientific investigation. It should be written in the past tense and contain only information which is relevant to the investigation.

REFERENCES

1. Any introductory college level physics text.
2. Any basic electricity text.